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Yamamoto et al.

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(54) **THRUST ROLLER BEARING CAGE AND METHOD FOR MANUFACTURING THE SAME**

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F16C 19/46 (2006.01)
(Continued)

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(52) **U.S. Cl.**
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(58) **Field of Classification Search**
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F16C 33/543; *F16C 33/545*; *F16C 33/546*
See application file for complete search history.

(73) Assignee: **NTN CORPORATION**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **15/523,408**

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JP 3037788 5/1997

(86) PCT No.: **PCT/JP2015/081273**

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(2) Date: **May 1, 2017**

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(87) PCT Pub. No.: **WO2016/080208**
PCT Pub. Date: **May 26, 2016**

(57) **ABSTRACT**

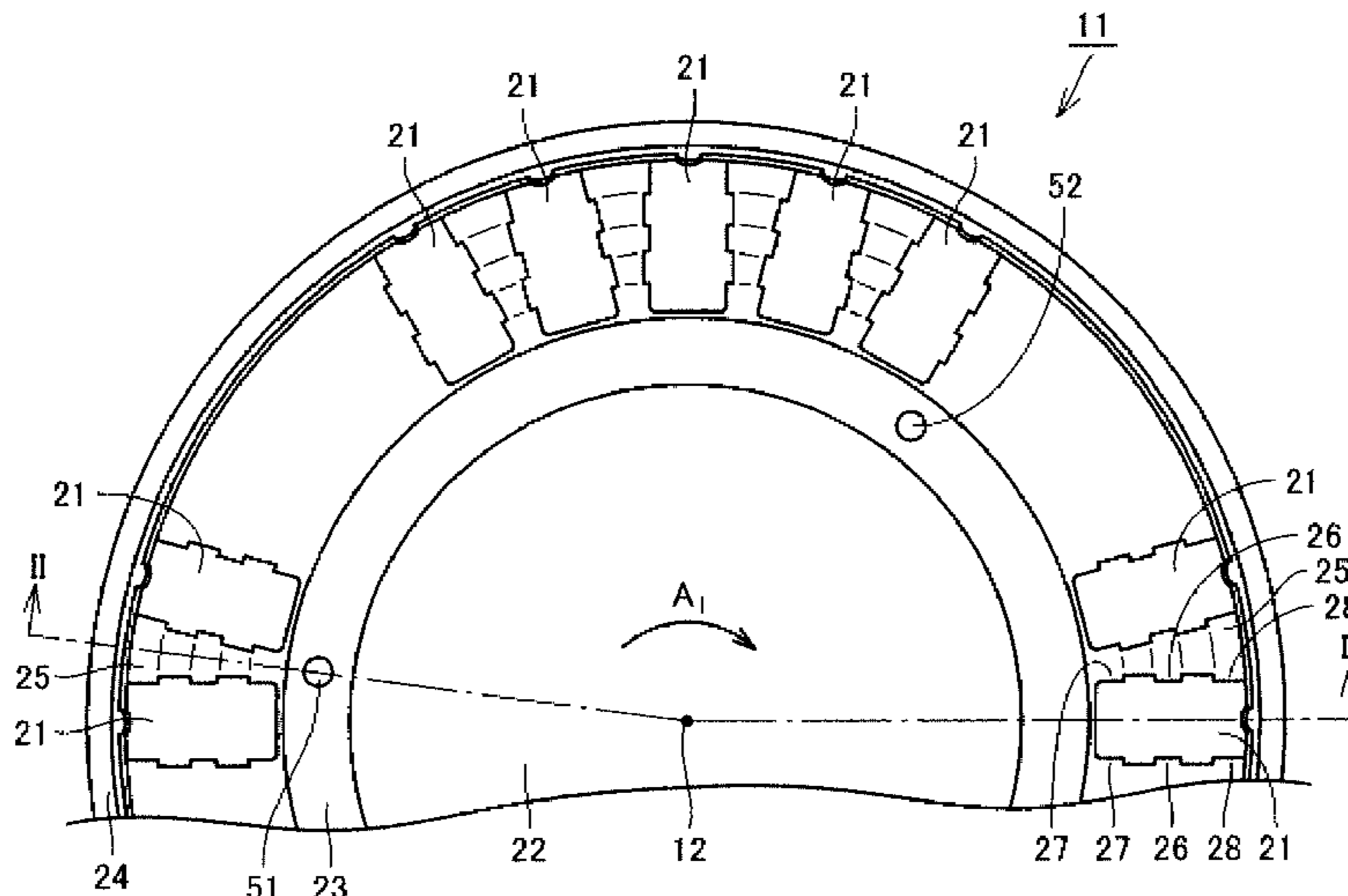
(65) **Prior Publication Data**
US 2017/0307007 A1 Oct. 26, 2017

A thrust roller bearing cage (11) of the present invention is included in a thrust roller bearing (20) and includes a plurality of pockets (21) accommodating rollers (13). The thrust roller bearing cage (11) includes: a radially outer area bent portion (41) formed by bending the cage (11) inward in a radial direction along an annular groove formed at a position radially outside the pockets (21); and projecting portions (44) that are formed in a tip end of the radially outer area bent portion (41) at positions aligned with the pockets (21) and project inward in the radial direction beyond radially outer edges of the pockets (21) so as to contact end faces (16) of the rollers (13) accommodated in the pockets (21). A trace (29) of the groove is left at a position along which the cage is bent.

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4 Claims, 8 Drawing Sheets



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F16C 33/54 (2006.01)

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FIG.1

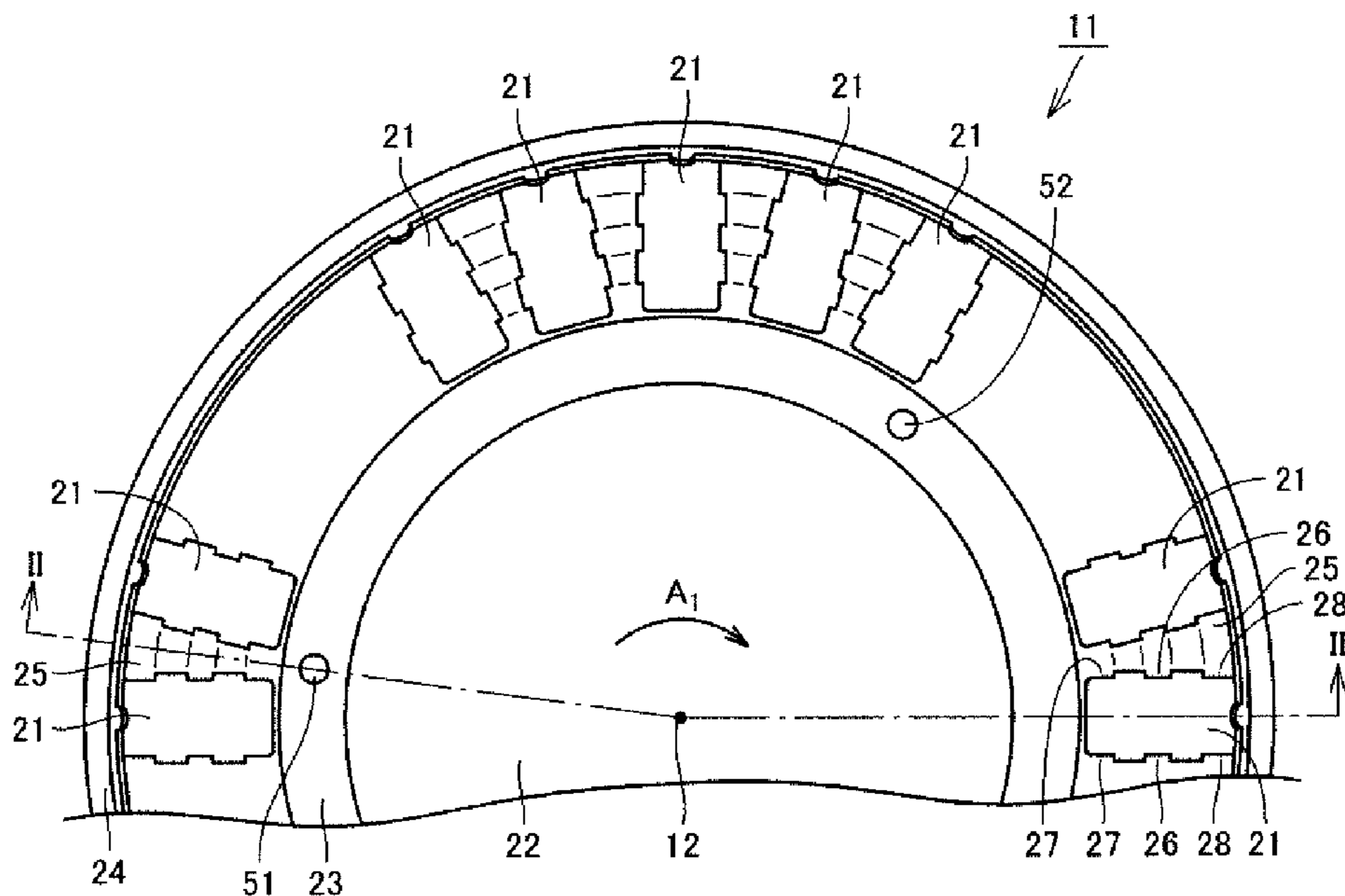


FIG.2

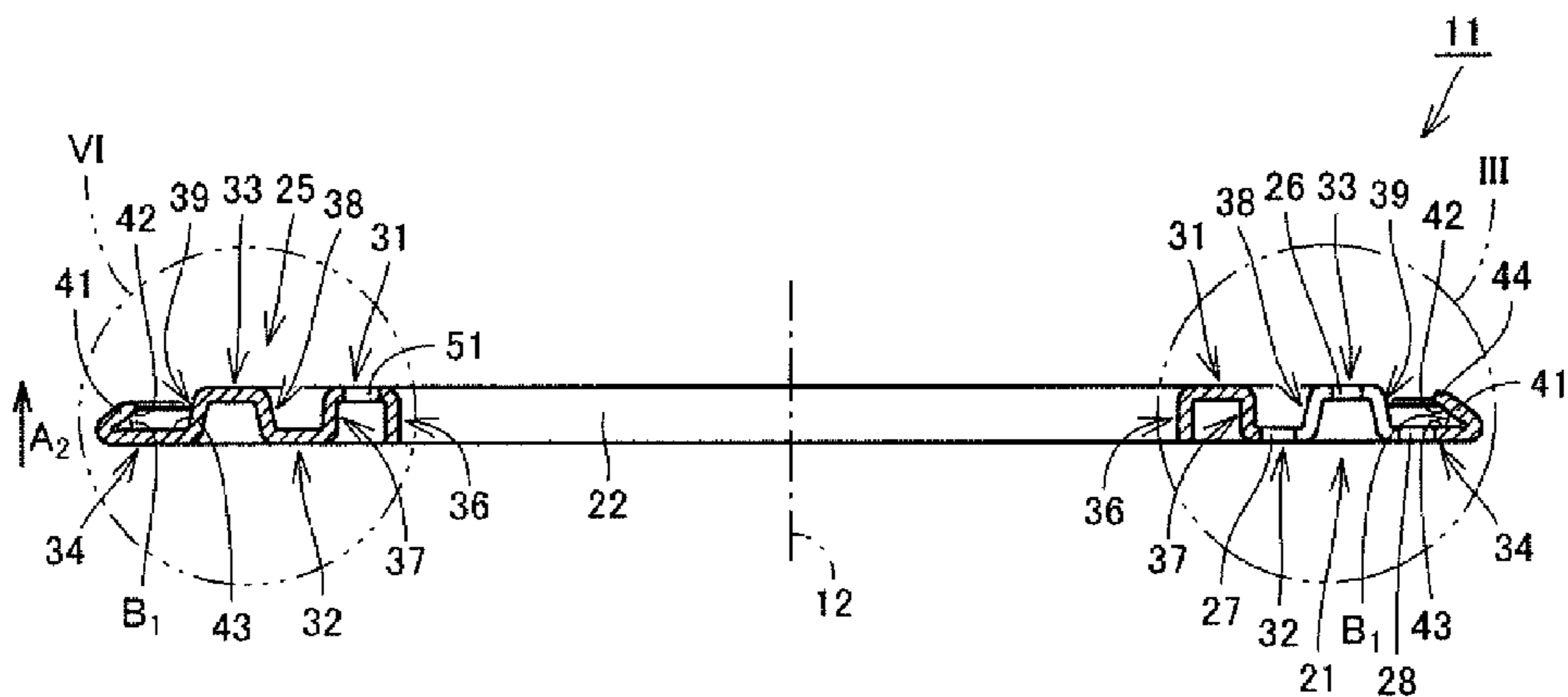


FIG.3

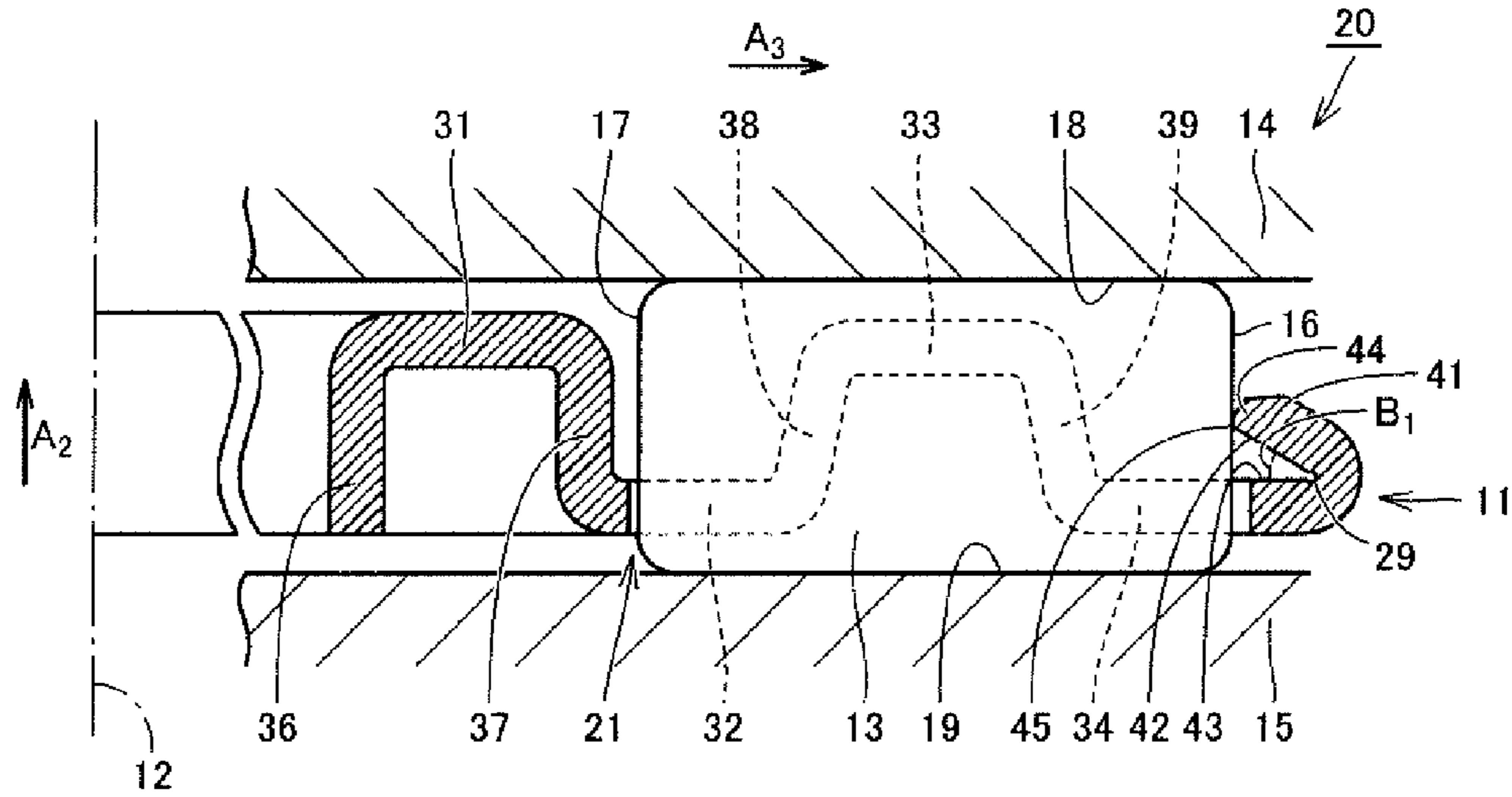


FIG.4

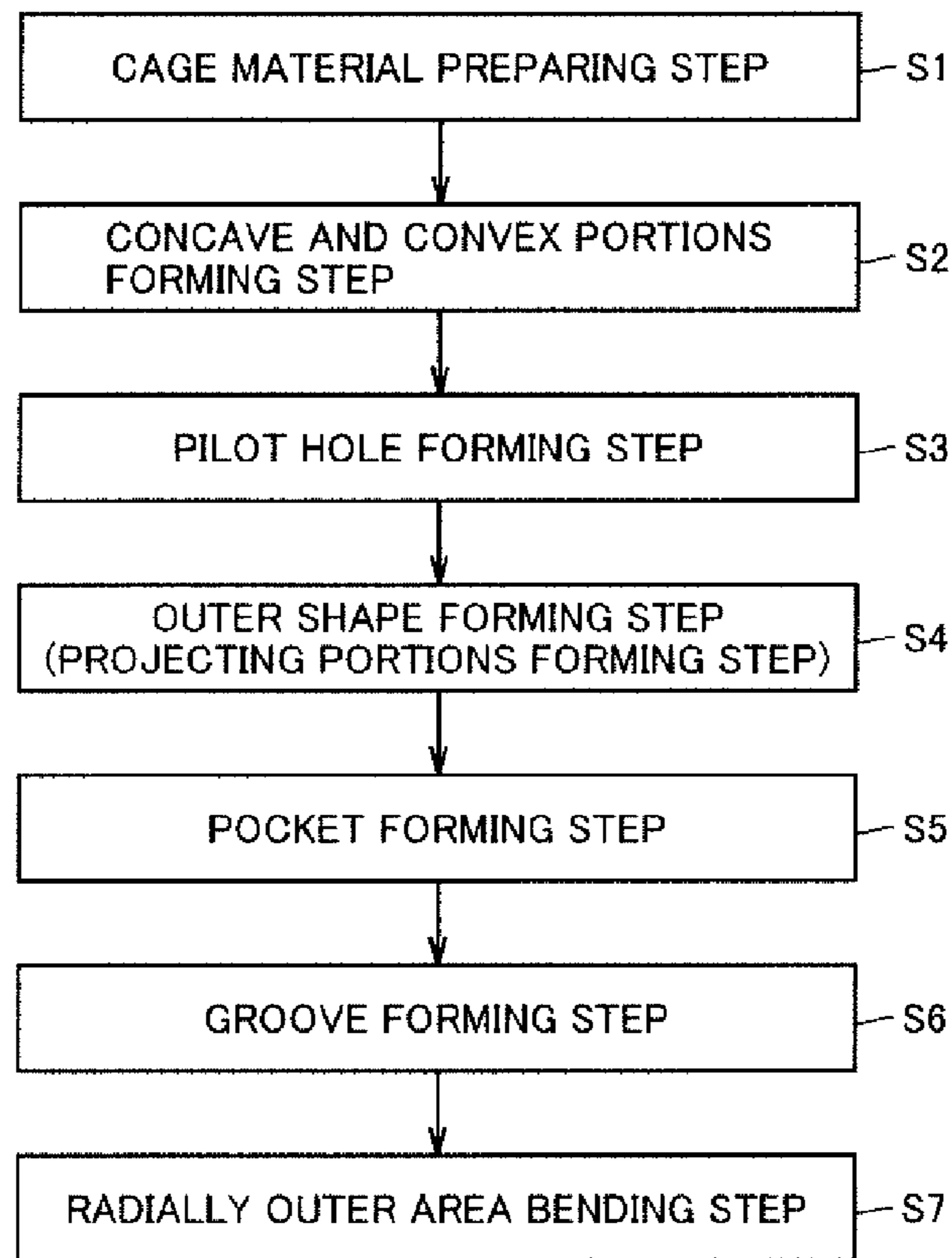


FIG.5

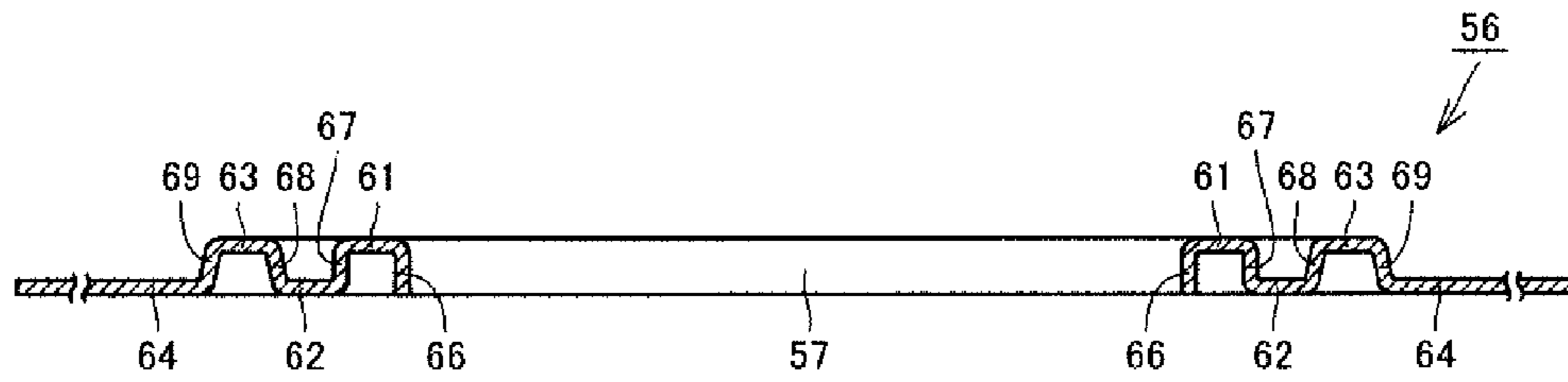


FIG.6

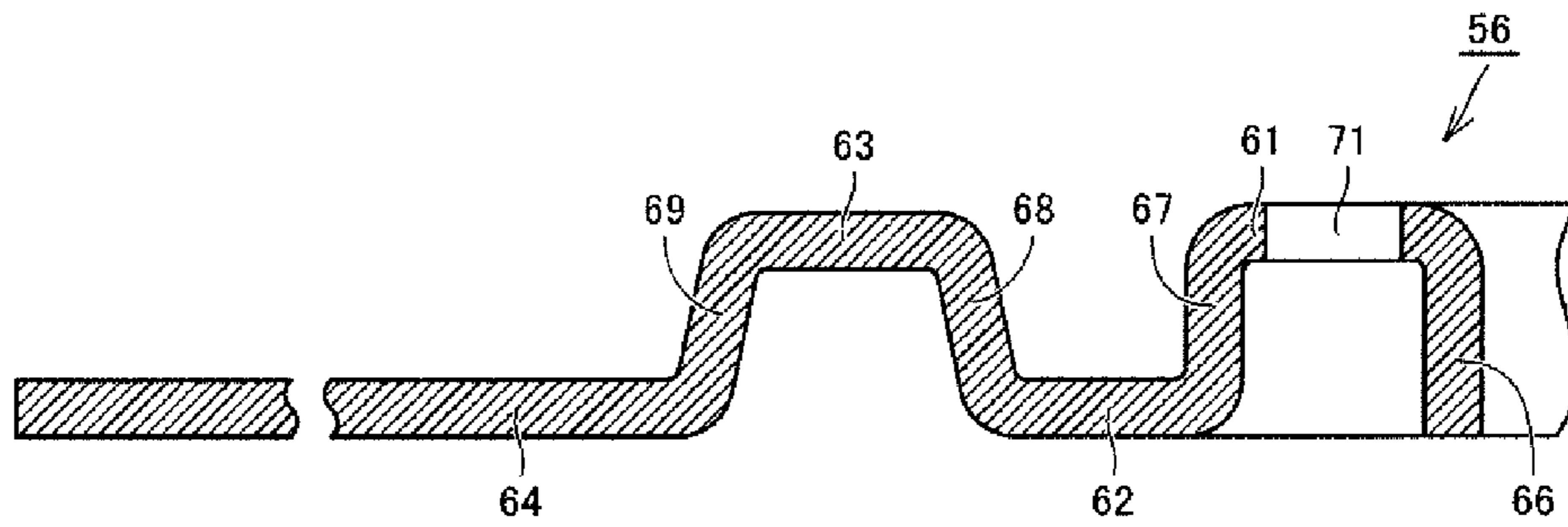


FIG.7

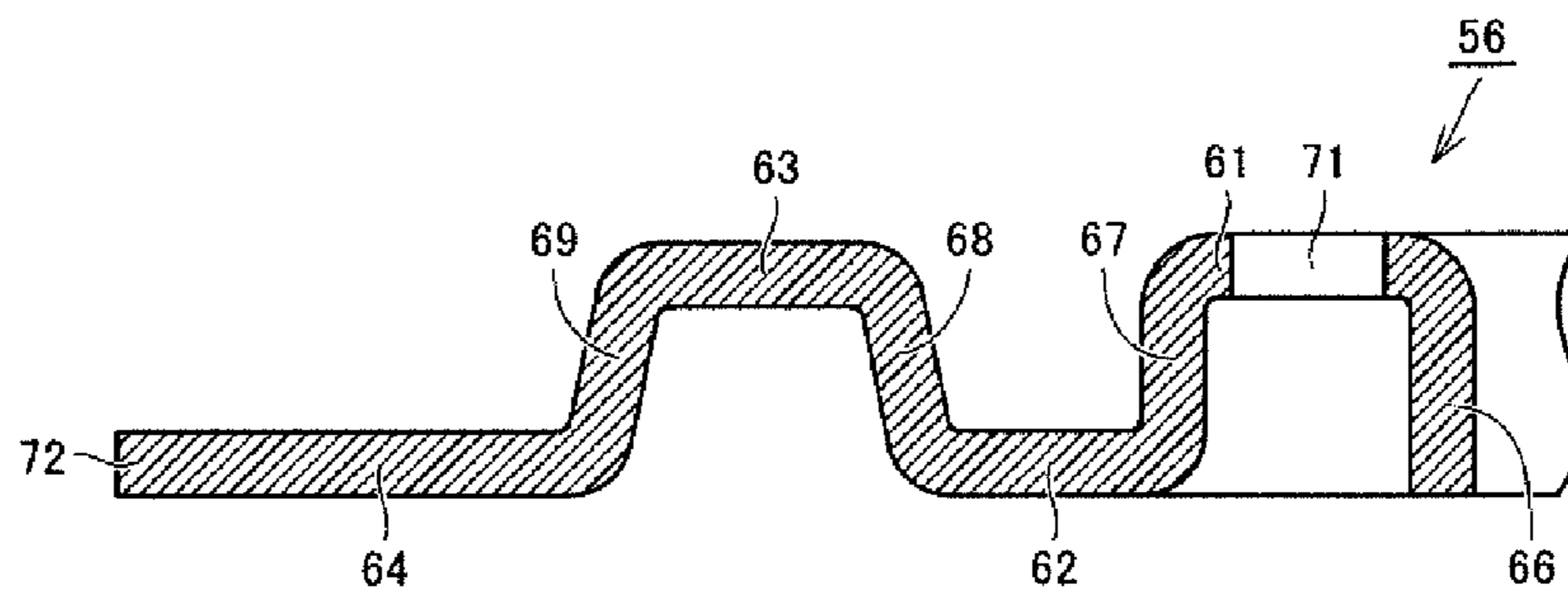


FIG.8

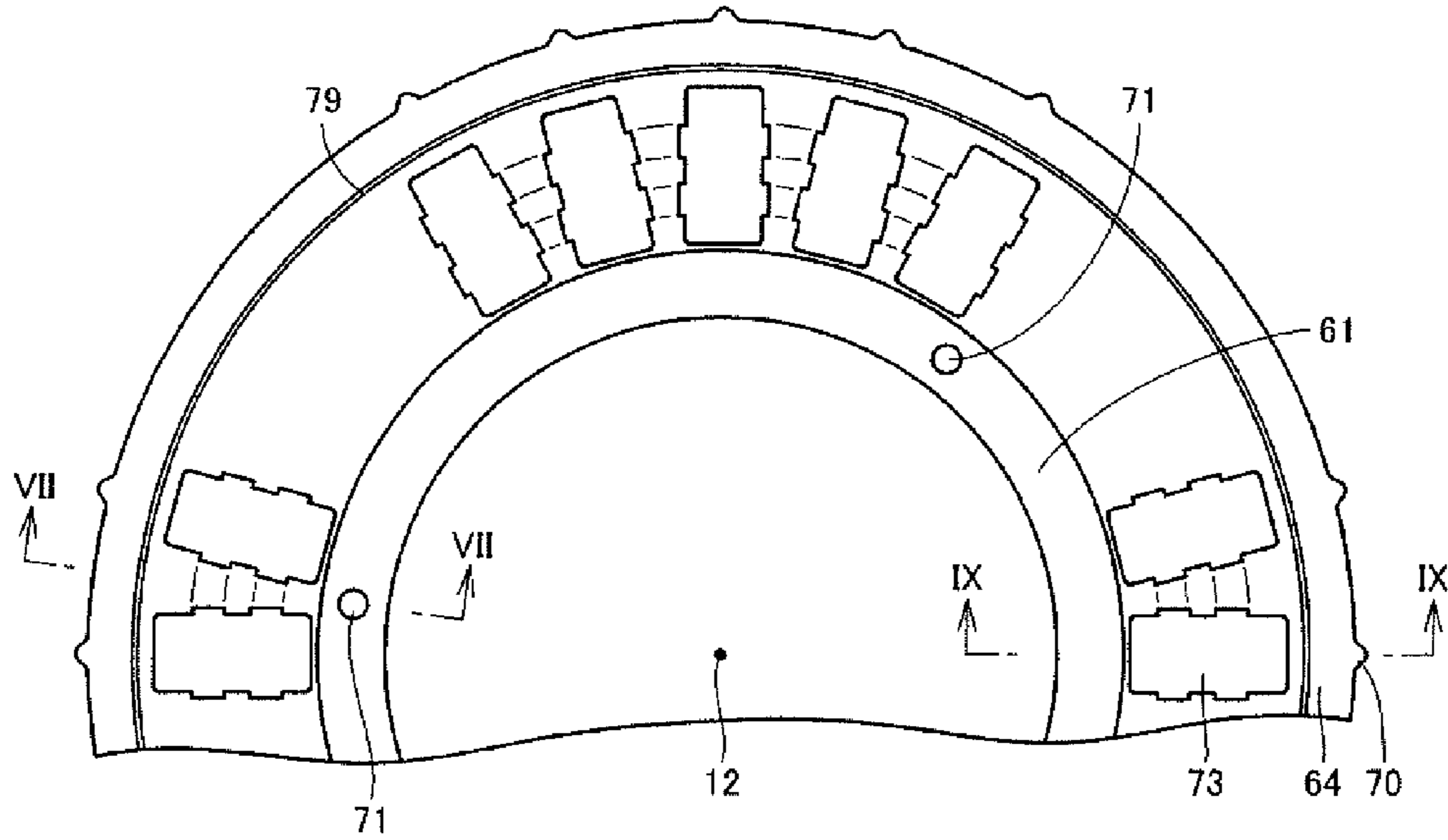


FIG.9

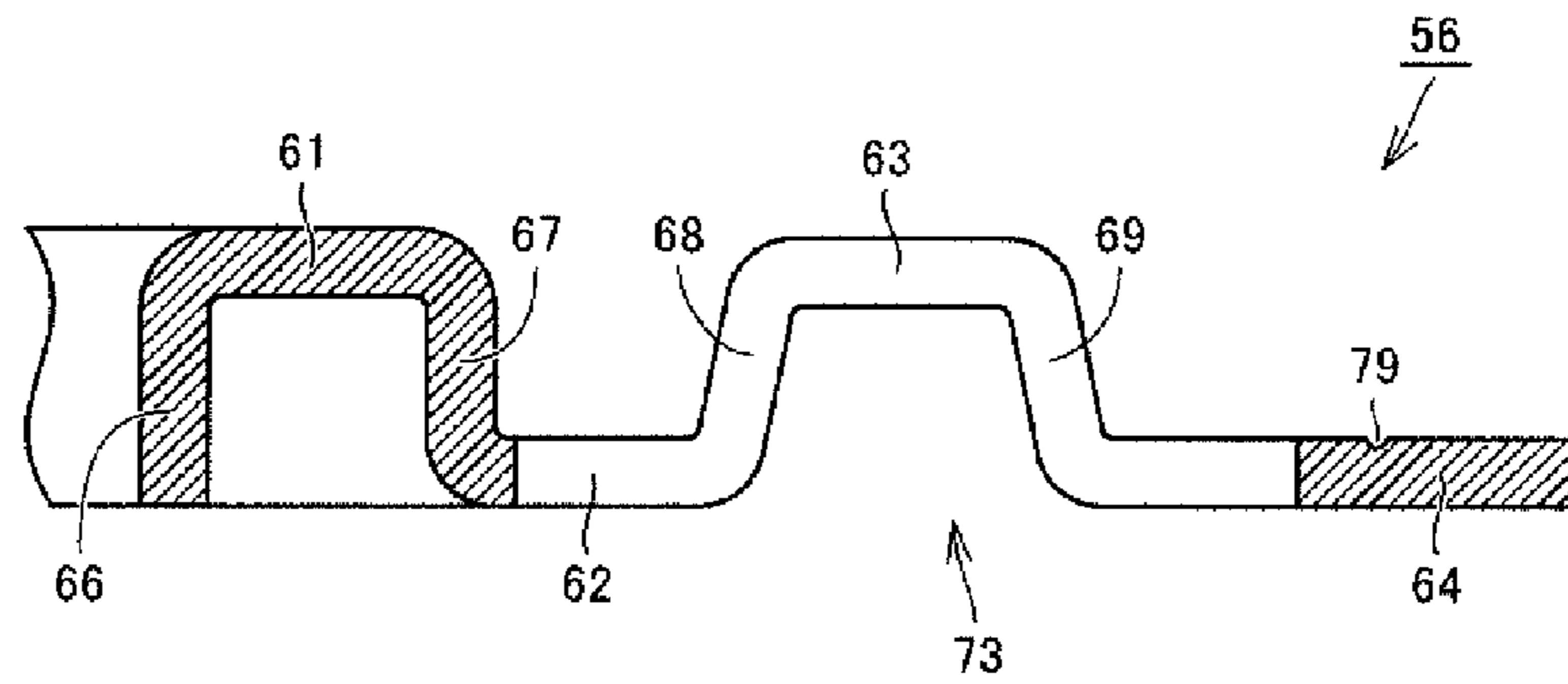


FIG.10

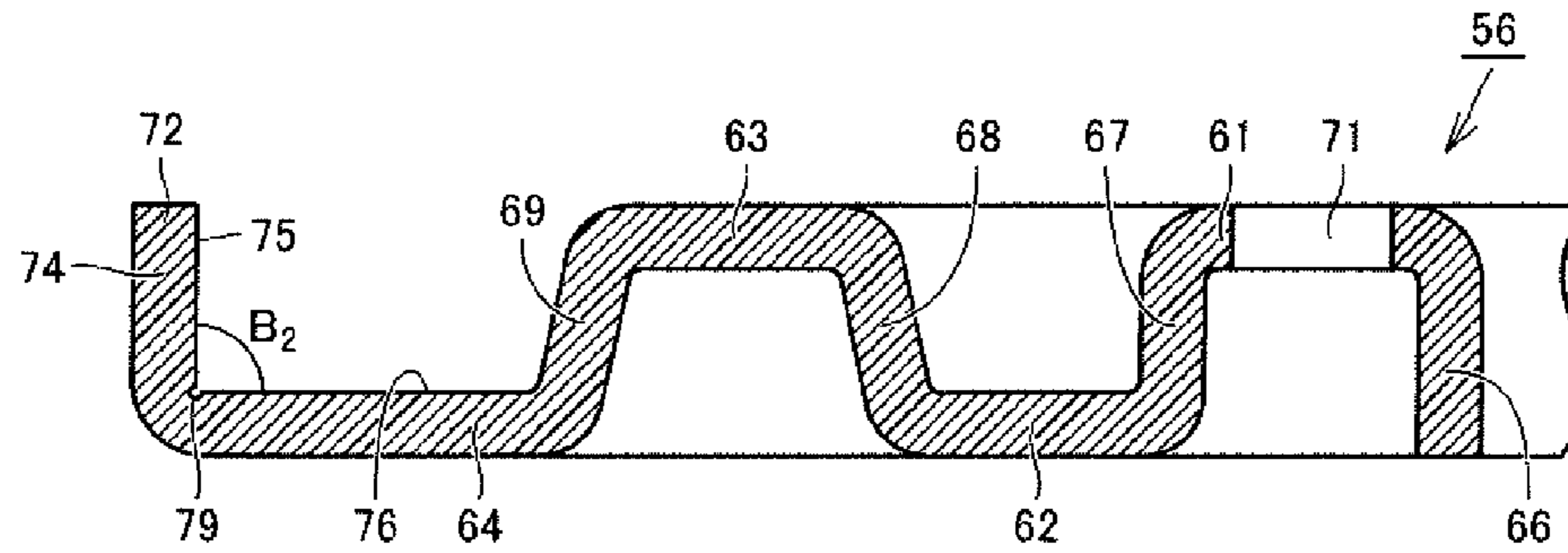


FIG.11

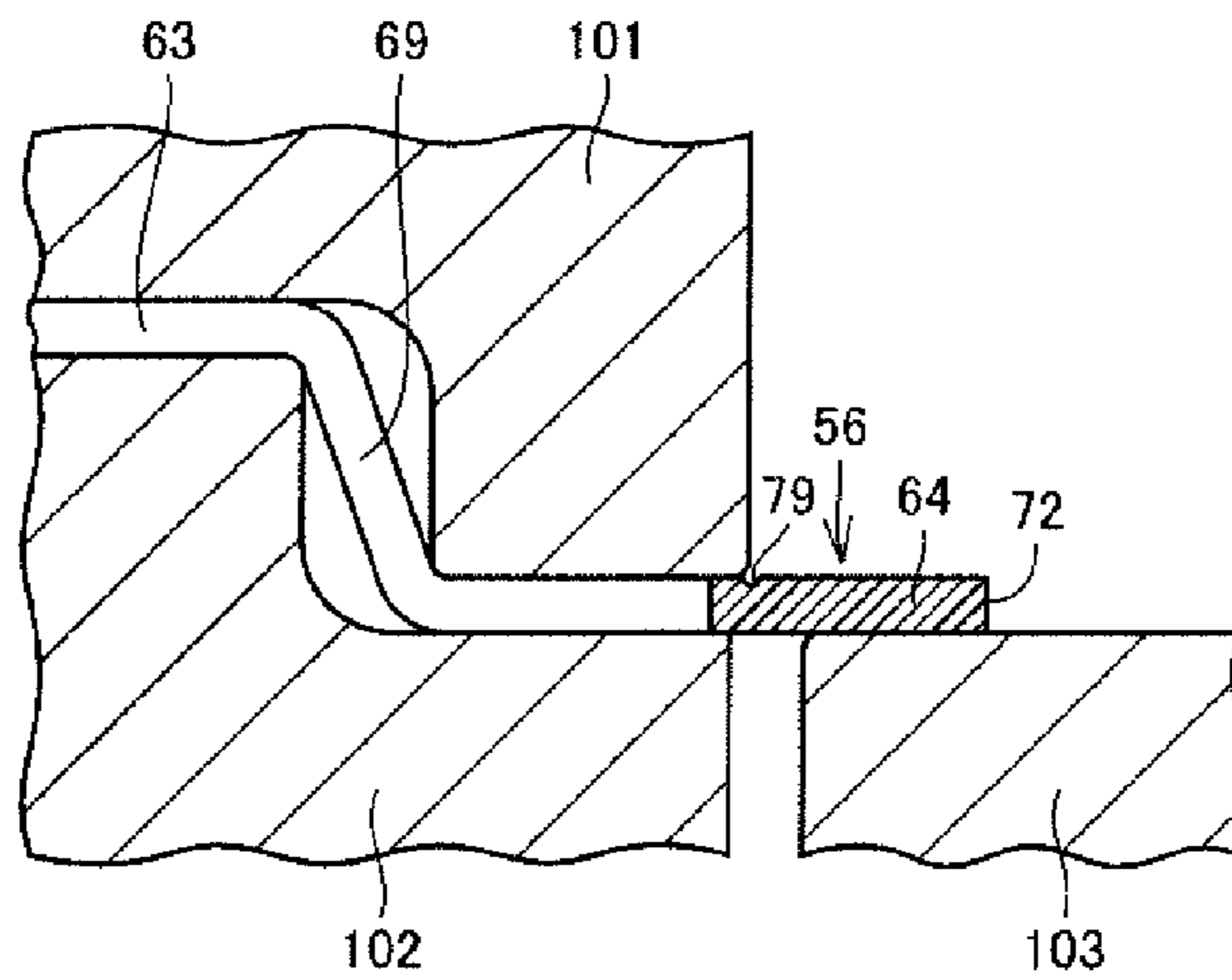


FIG.12

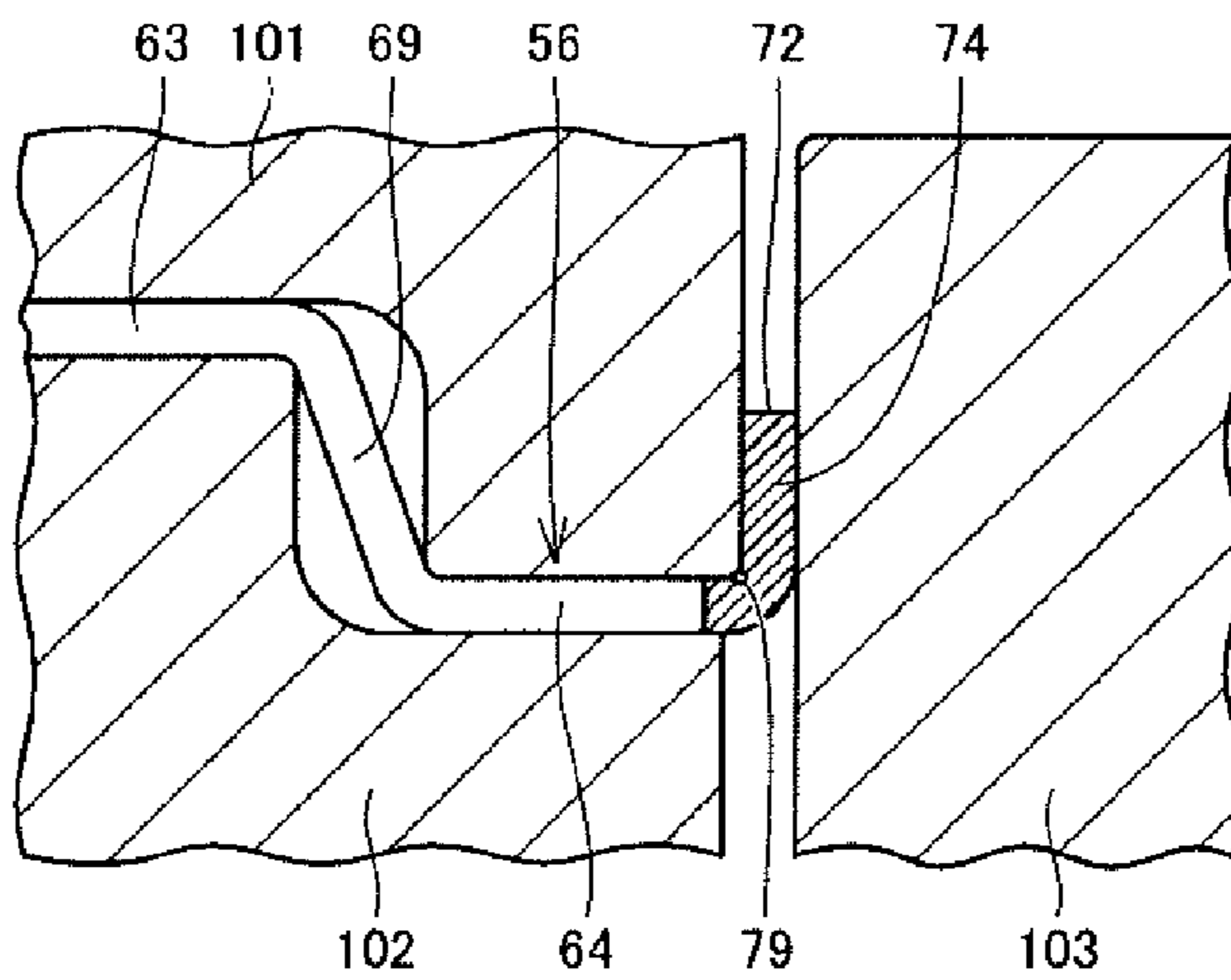


FIG.13

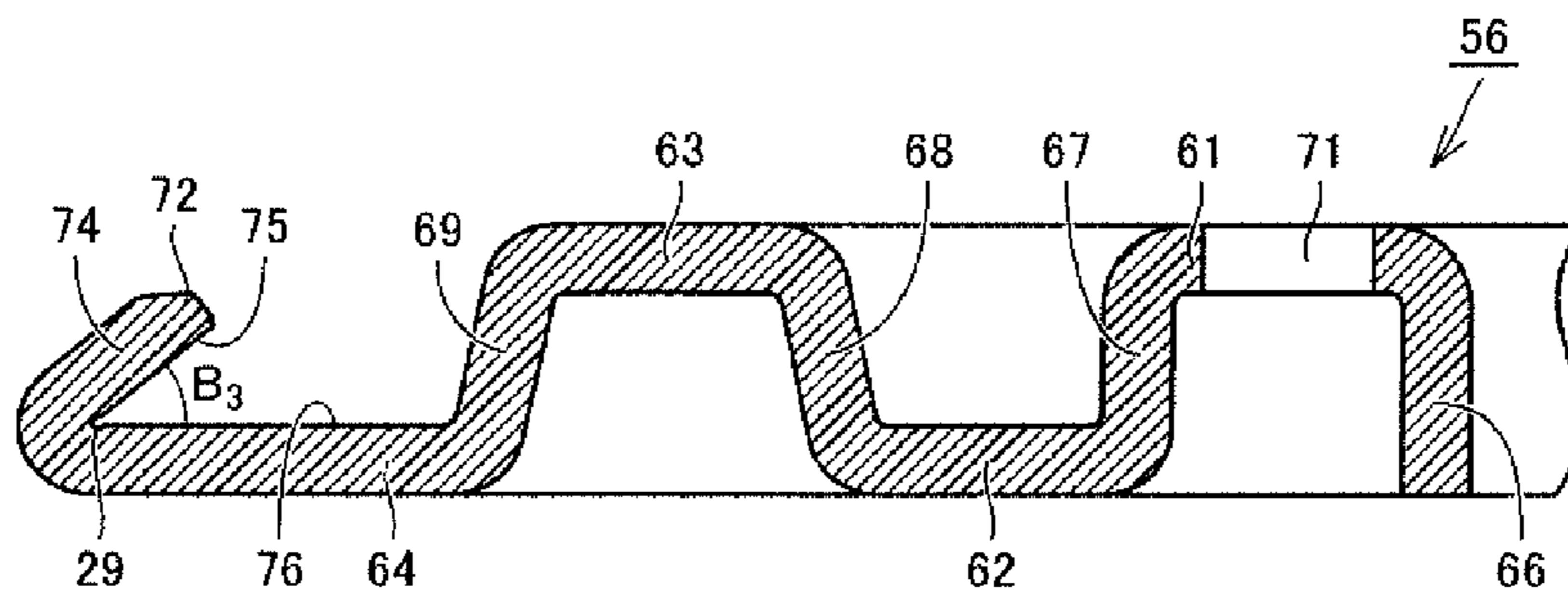


FIG.14

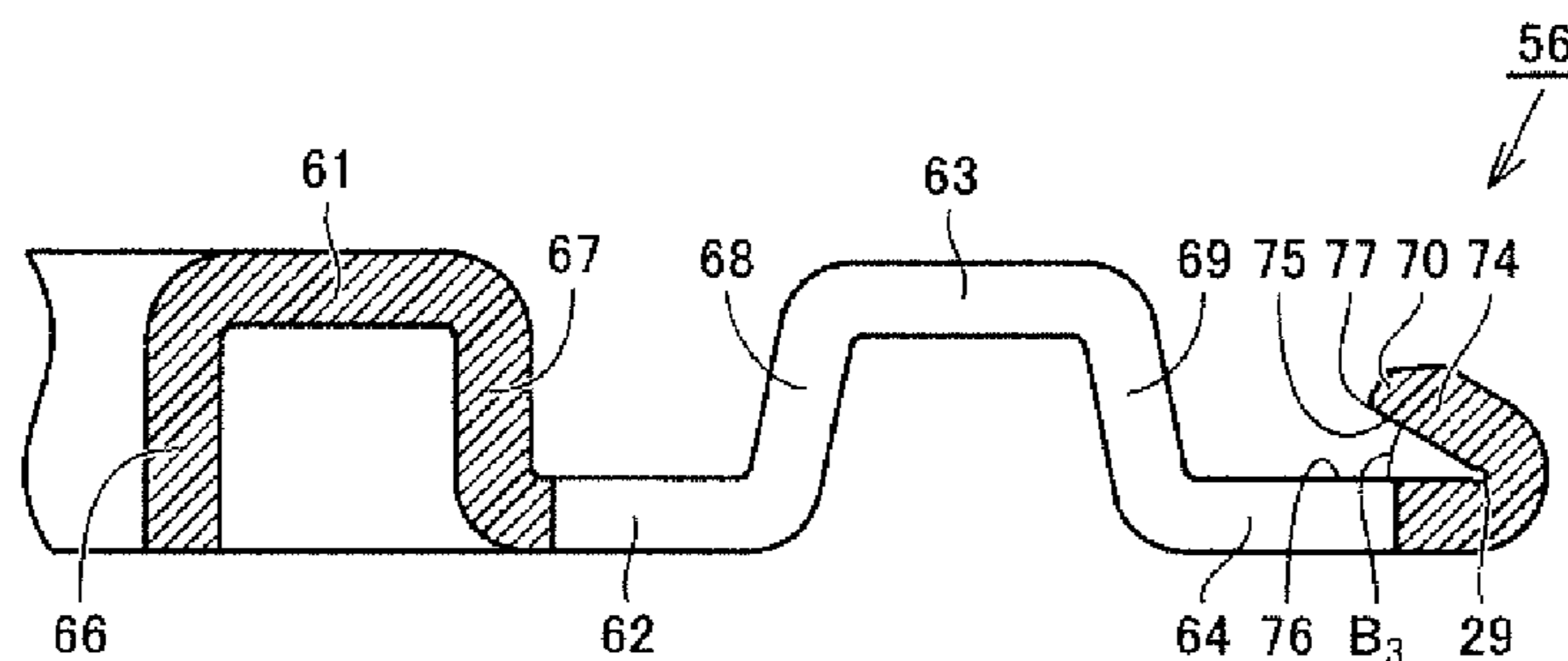


FIG.15

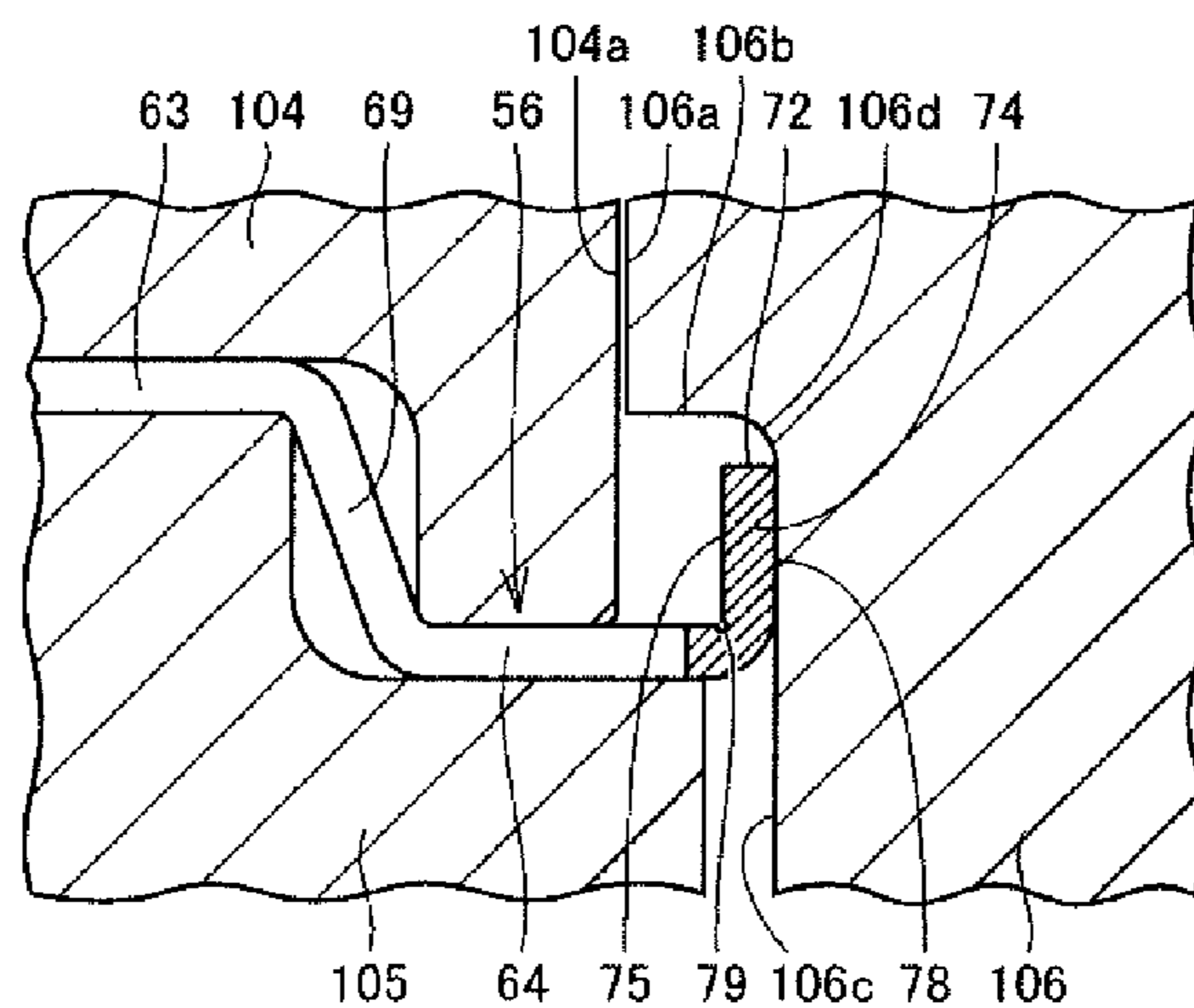


FIG.16

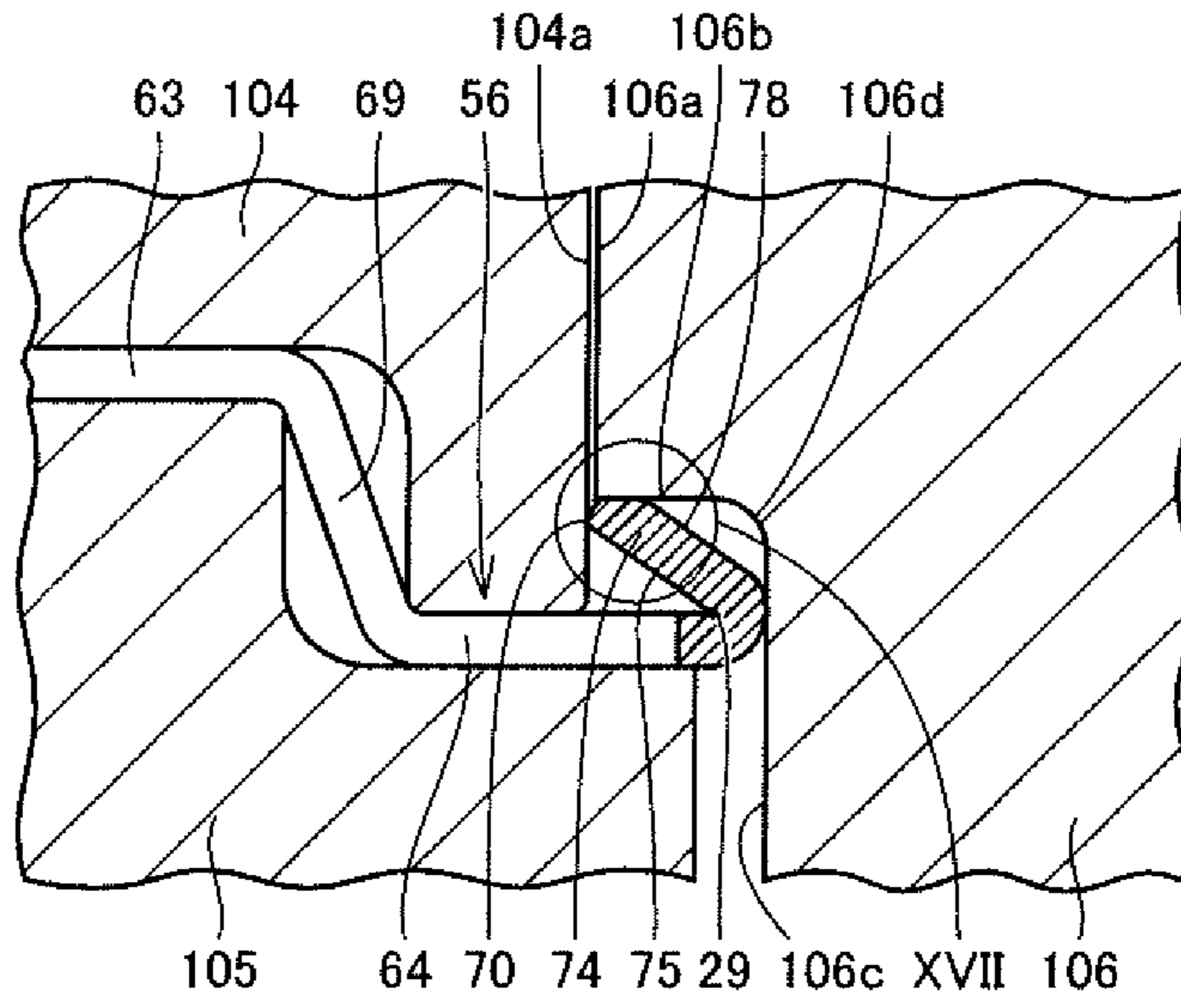


FIG.17

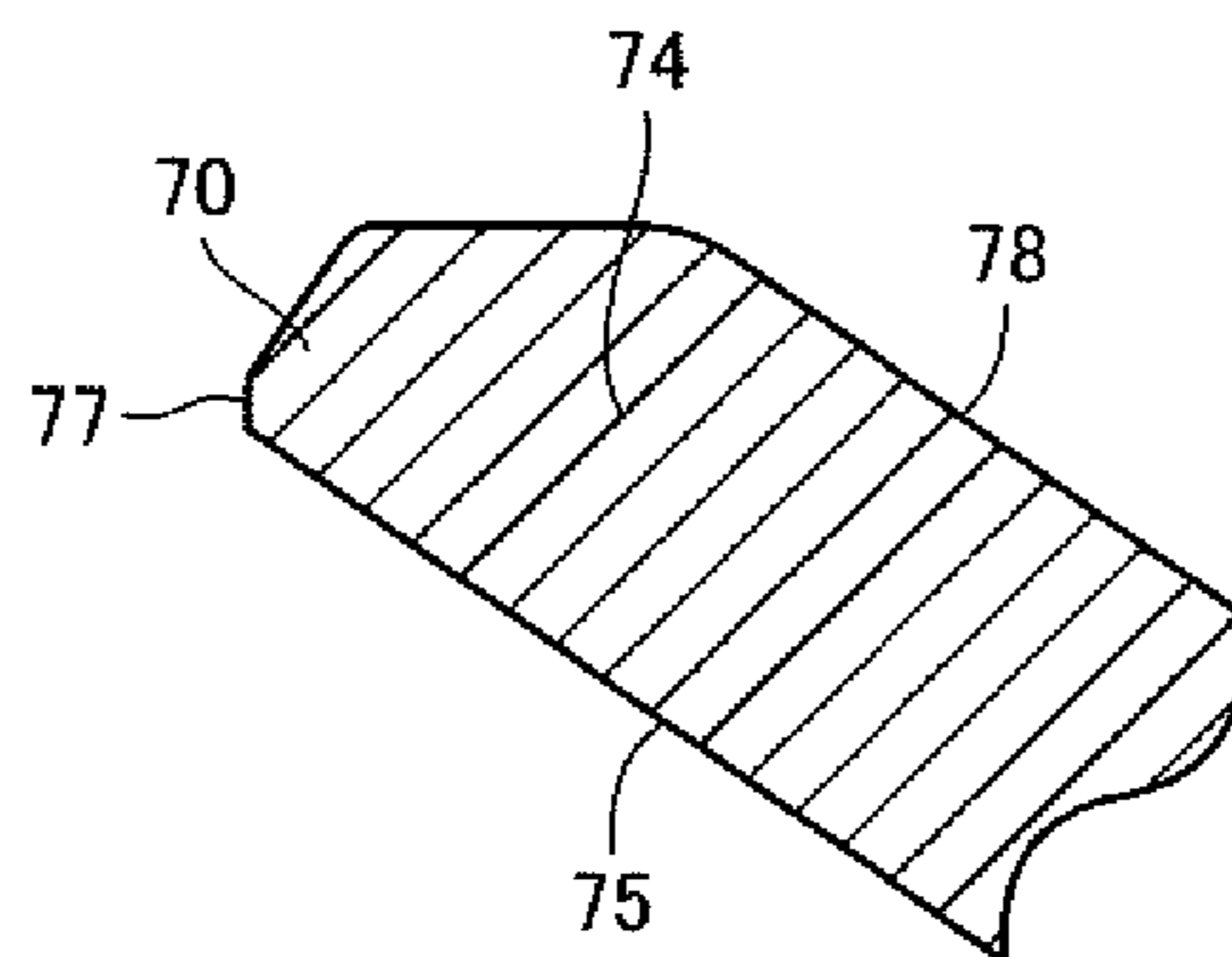


FIG.18

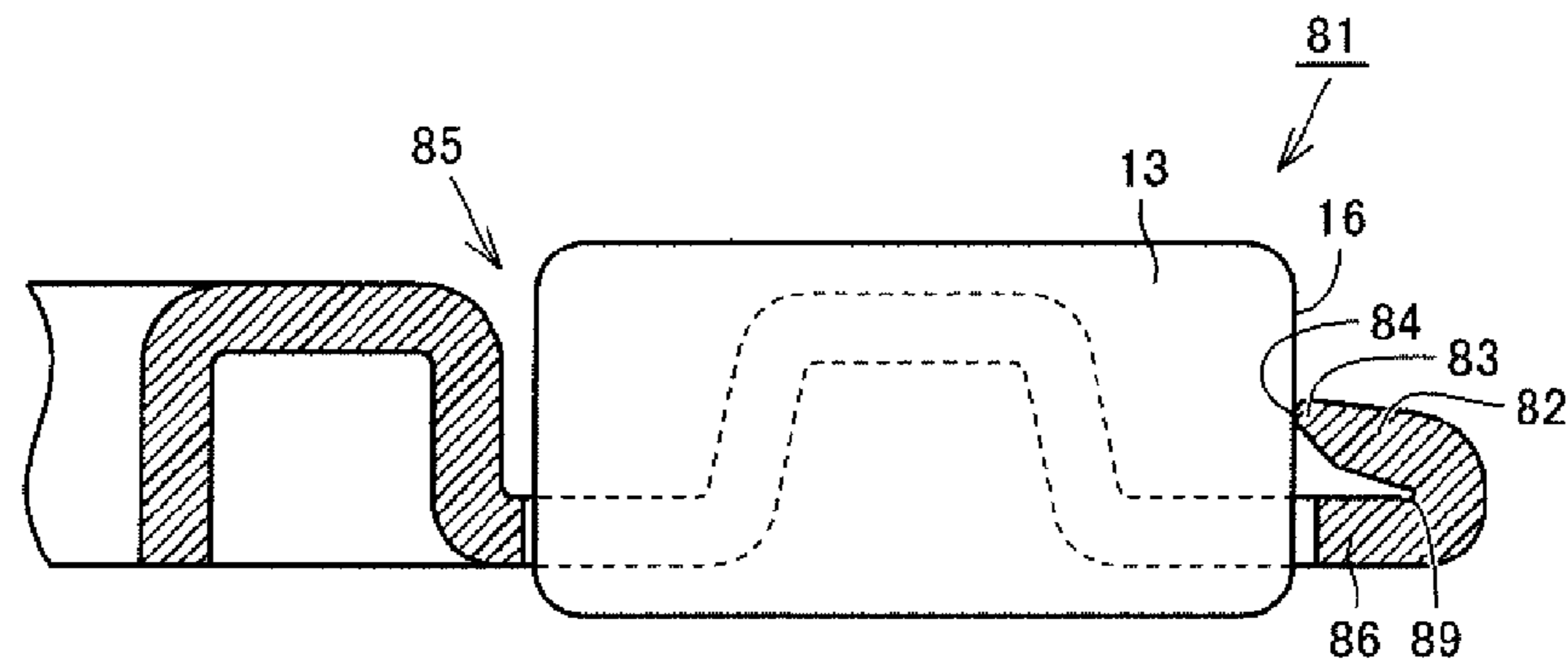
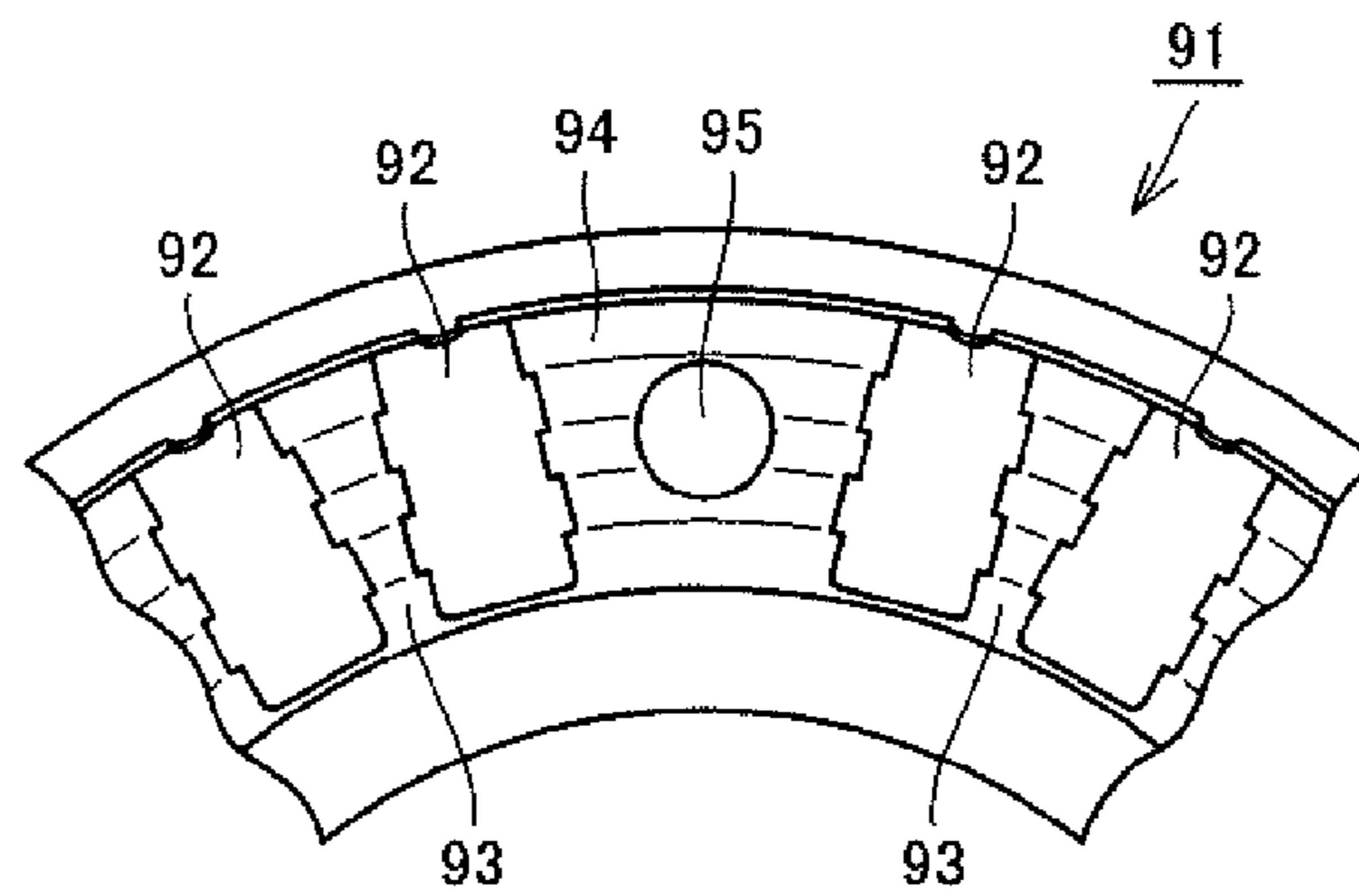


FIG.19



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THRUST ROLLER BEARING CAGE AND METHOD FOR MANUFACTURING THE SAME

TECHNICAL FIELD

The present invention relates to thrust roller bearing cages (hereinafter sometimes simply referred to as the "cages") and methods for manufacturing the same, and more particularly relates to a thrust roller bearing cage that is manufactured by using a press and a method for manufacturing the same.

BACKGROUND ART

For example, thrust roller bearings that support thrust loads are sometimes placed at such locations in automatic transmissions for automobiles, car air conditioner compressors, etc. that are subjected to thrust loads. For improved fuel efficiency and power saving, it is desired to reduce running torque of such thrust roller bearings. A thrust roller bearing includes bearing rings arranged in the direction of the rotation axis of the thrust roller bearing, a plurality of needle rollers that roll on raceway surfaces of the bearing rings, and a cage that retains the plurality of needle rollers. Some cages are manufactured by bending a steel sheet and then punching out pockets that accommodate the rollers.

A technique relating to the cages included in such thrust roller bearings is disclosed in, e.g., Japanese Unexamined Patent Publication No. H10-220482 (Patent Literature 1). The thrust roller bearing cage of Patent Literature 1 includes an annular body formed by cutting, punching, etc. and projecting portions formed in a radially outer part of the annular body. The projecting portions are formed such that those parts of the radially outer end face of the folded part of the annular body which are located at the positions of the pockets project inward in the radial direction, and the tip ends of the projecting portions face approximately the centers of the end faces of the rollers.

CITATION LIST

Patent Literatures

Patent Literature 1: Japanese Unexamined Patent Application Publication No. H10-220482

SUMMARY OF INVENTION

Technical Problem

In order to reduce running torque, it is desirable that the tip ends of the projecting portions contact approximately the centers of the radially outer end faces of the rollers in Patent Literature 1. In Patent Literature 1, however, the tip ends of the projecting portions are sometimes displaced from their desired positions, and in such a case, the running torque is not sufficiently reduced.

It is an object of the present invention to provide a thrust roller bearing cage that reduces running torque and a method for manufacturing the same.

Solution to Problem

The inventors found out the reason why the tip ends of the projecting portions do not contact the centers of the radially outer end faces of the rollers in Patent Literature 1. Since

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the folded part of the annular body, which is located outside the folding position in the radial direction, has a small length in the radial direction, namely since the height of the folded part is small, it is difficult to fold the annular body, and the folding position is displaced from its desired position. The inventors completed the present invention through their intensive research regarding means for improving accuracy of the folding position of the annular body and easily folding the annular body.

A thrust roller bearing cage according to the present invention is a thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers. The thrust roller bearing cage includes: a radially outer area bent portion formed by bending the cage inward in a radial direction along an annular groove formed at a position radially outside the pockets; and projecting portions that are formed in a tip end of the radially outer area bent portion at positions aligned with the pockets and project inward in the radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets. A trace of the groove is left at a position along which the cage is bent.

A method for manufacturing a thrust roller bearing cage according to the present invention is a method for manufacturing a thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers. The method includes the steps of: preparing a cage material that will later become the cage; forming an outer shape of the cage material so that the outer shape has portions that will later become projecting portions projecting inward in a radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets; forming the pockets in the cage material; forming an annular groove at a position radially outside the pockets in the cage material; and forming a radially outer area bent portion by bending an area of the cage material which is located radially outside the pockets inward in the radial direction along the annular groove.

According to the thrust roller bearing cage of the present invention and the method for manufacturing the same, the radially outer area bent portion is formed by bending the cage inward in the radial direction along the annular groove formed at the position radially outside the pockets. Since the annular groove serves as a bending position, displacement of the bending position can be prevented. Moreover, the annular groove facilitates bending even when the height of the bent portion is small. Since the annular groove improves positional accuracy of the radially outer area bent portion and facilitates bending, the projecting portions formed in the tip end of the radially outer area bent portion can contact approximately the centers of the radially outer end faces of the rollers, whereby running torque can be reduced.

In the thrust roller bearing cage according to the present invention, it is preferable that areas of the projecting portions which are to contact the end faces of the rollers be subjected to a press-flattening process.

It is preferable that the method for manufacturing the thrust roller bearing cage according to the present invention further includes the step of: press-flattening areas of the projecting portions which are to contact the end faces of the rollers.

Since the areas of the projecting portions which are to contact the end faces of the rollers are subjected to the press-flattening process, this can reduce the risk that discontinuity of a lubricant film will be caused during rotation of the bearing by the sliding motion of the end faces of the

rollers on the areas of the projecting portions which contact the end faces of the rollers. This improves lubricating properties in the contact areas and reduces what is called aggression of the rollers against the projecting portions of the cage. Such a thrust roller bearing cage can thus further reduce the running torque of the bearing.

As used herein, the "press-flattening process" means a process in which, in the step of forming the radially outer area bent portion, the projecting portions are pressed outward in the radial direction by using a radially outer surface of a die that serves as a stopper to control the amount of collapse, in order to smooth the rough surfaces of the projecting portions before and after the process. Specifically, the press-flattening process can smooth a press-sheared surface or a fracture surface, which is formed in the step of forming the outer shape, to arithmetic mean roughness Ra (JIS B 0601) of about 2 μm or less.

Advantageous Effects of Invention

According to the thrust roller bearing cage of the present invention and the method for manufacturing the same, running torque can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows a part of a thrust roller bearing cage according to an embodiment of the present invention.

FIG. 2 is a sectional view of the thrust roller bearing cage shown in FIG. 1.

FIG. 3 is an enlarged sectional view showing a part of the thrust roller bearing cage shown in FIG. 2.

FIG. 4 is a flowchart illustrating representative steps of a method for manufacturing the thrust roller bearing cage according to the embodiment of the present invention.

FIG. 5 is a sectional view of a cage material after a concave and convex portions forming step.

FIG. 6 is an enlarged sectional view showing a part of the cage material after a pilot hole forming step.

FIG. 7 is an enlarged sectional view showing a part of the cage material after an outer shape forming step.

FIG. 8 shows a part of the cage material after a pocket forming step.

FIG. 9 is an enlarged sectional view showing a part of the cage material after the pocket forming step.

FIG. 10 is an enlarged sectional view showing a part of the cage material during a radially outer area bending step.

FIG. 11 is an enlarged sectional view illustrating how the radially outer area bending step is performed.

FIG. 12 is an enlarged sectional view illustrating how the radially outer area bending step is performed.

FIG. 13 is an enlarged sectional view showing a part of the cage material after the radially outer area bending step.

FIG. 14 is an enlarged sectional view showing a part of the cage material after the radially outer area bending step.

FIG. 15 is an enlarged sectional view illustrating how the radially outer area bending step is performed.

FIG. 16 is an enlarged sectional view illustrating how a press-flattening step is performed.

FIG. 17 is an enlarged sectional view showing the tip of a radially outer area bent portion after the press-flattening step.

FIG. 18 is a sectional view showing a part of a thrust roller bearing cage according to another embodiment of the present invention.

FIG. 19 shows a part of a thrust roller bearing cage according to still another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

Embodiments of the present invention will be described below with reference to the drawings. In the figures described below, the same or corresponding portions are denoted with the same reference characters, and description thereof will not be repeated.

FIG. 1 shows a part of a thrust roller bearing cage **11** according to an embodiment of the present invention. FIG. 1 shows the cage **11** as viewed in the direction of the rotation axis of the cage **11**. FIG. 2 is a sectional view of the thrust roller bearing cage **11** shown in FIG. 1. FIG. 2 shows the cage **11** taken along line II-II in FIG. 1. Specifically, a portion having a pocket, which will be described later, is shown in section on the right side of FIG. 2, and a portion having a pillar, which will be described later, is shown in section on the left side of FIG. 2. FIG. 3 is an enlarged sectional view showing a part of the thrust roller bearing cage **11** shown in FIG. 2. The enlarged sectional view in FIG. 3 shows the area indicated by III in FIG. 2. In FIGS. 2 and 3, the rotation axis **12** of the cage **11** is shown by an alternate long and short dash line. For ease of understanding, FIG. 3 shows a needle roller **13** accommodated in a pocket **21** that will be described later, and a part of a pair of bearing rings **14**, **15** disposed on both sides of the cage **11** in the direction of the rotation axis of the cage **11**. The direction perpendicular to the plane of paper of FIG. 1 and the vertical direction in FIGS. 2 and 3 are the direction of the rotation axis of the cage **11**. The direction shown by arrow A_1 or its opposite direction in FIG. 1 is the circumferential direction. For ease of understanding, the upper side in FIGS. 2 and 3 is defined as the upper side in the axial direction. That is, the direction shown by arrow A_2 in FIGS. 2 and 3 is the upward direction. The lateral direction in FIGS. 2 and 3 is the radial direction. The direction shown by arrow A_3 in FIG. 3 is the radially outward direction.

First, the configuration of the thrust roller bearing cage **11** according to the embodiment of the present invention will be described with reference to FIGS. 1 to 3. The thrust roller bearing cage **11** according to the embodiment of the invention is in the shape of a disc and has a through bore **22** extending straight through its central area in the thickness direction of the cage **11**. A rotary shaft, not shown, is inserted through the through bore **22**.

The cage **11** includes a pair of annular portions **23**, **24** with different diameters, and a plurality of pillars **25** formed at intervals in the circumferential direction so as to form the pockets **21** that accommodate the needle rollers **13** therein and connecting the pair of annular portions **23**, **24**. In this example, the cage **11** has 28 pockets **21** and 28 pillars **25**, although not all of the pockets **21** and the pillars **25** are shown in the figures.

The pockets **21** are substantially rectangular as viewed in the axial direction. The pockets **21** are arranged radially about the rotation axis **12** of the cage **11**. The pockets **21** have upper roller stoppers **26** and lower roller stoppers **27**, **28** on their side wall surfaces. The upper roller stoppers **26** prevent the needle rollers **13** accommodated in the pockets **21** from falling out upward in the axial direction, while the lower roller stoppers **27**, **28** prevent the needle rollers **13** accommodated in the pockets **21** from falling out downward in the axial direction. The upper roller stoppers **26** are formed in the middle parts in the radial direction of the

pockets 21. The lower roller stoppers 27 are formed in the radially inner parts of the pockets 21, and the lower roller stoppers 28 are formed in the radially outer parts of the pockets 21. The upper roller stoppers 26 and the lower roller stoppers 27, 28 are formed on the side wall surfaces located on both sides in the circumferential direction of each pocket 21 so as to project into the pockets 21.

The needle rollers 13 are pressed into the pockets 21 to fit in the pockets 21. End faces of each needle roller 13, specifically, an outer end face 16 in the bearing and an inner end face 17 in the bearing, are flat.

The cage 11 has concave and convex portions that are formed by bending a plate in the thickness direction thereof a few times. Specifically, the cage 11 includes four disc portions 31, 32, 33, 34 extending in the radial direction and four cylindrical portions 36, 37, 38, 39 extending in the axial direction. The four disc portions 31 to 34 are arranged in this order from the inside in the radial direction so that the first disc portion 31 has the smallest inside diameter, followed by the second disc portion 32, the third disc portion 33, and the fourth disc portion 34 in ascending order. The four cylindrical portions 36 to 39 are arranged in order of the first cylindrical portion 36, the second cylindrical portion 37, the third cylindrical portion 38, and the fourth cylindrical portion 39 from the inside in the radial direction. The first cylindrical portion 36 and the second cylindrical portion 37 extend straight in the axial direction. The third cylindrical portion 38 is slightly tilted so that its radially inner part is located below its radially outer part in the axial direction. The fourth cylindrical portion 39, which is the outermost cylindrical portion in the radial direction, is slightly tilted so that its radially inner part is located above its radially outer part in the axial direction. The upper roller stoppers 26 are formed in the third disc portion 33. The lower roller stoppers 27 are formed in the second disc portion 32, and the lower roller stoppers 28 are formed in the fourth disc portion 34. The inner annular portion 23 in the radial direction includes the first disc portion 31, a part of the second disc portion 32, the first cylindrical portion 36, and the second cylindrical portion 37. The outer annular portion 24 in the radial direction includes a part of the fourth disc portion 34, a radially outer area bent portion 41, and projecting portions 44. The radially outer area bent portion 41 and the projecting portions 44 will be described later. Each pillar 25 includes a part of the second disc portion 32, the third disc portion 33, a part of the fourth disc portion 34, the third cylindrical portion 38, and the fourth cylindrical portion 39.

The cage 11 includes the radially outer area bent portion 41 that is formed by bending a radially outer area of the cage 11 inward in the radial direction. The radially outer area bent portion 41 is a standing wall standing in the axial direction and is formed to extend continuously in an annular shape. Specifically, the radially outer area bent portion 41 is formed by bending the radially outer area of the cage 11 inward in the radial direction along an annular groove formed at a position radially outside the pockets 21. As shown in FIG. 3, a trace 29 of the annular groove along which the radially outer area of the cage 11 is bent is left in the cage 11. The trace 29 is a portion with a reduced thickness, a compression mark, etc.

The radially outer area bent portion 41 of the present embodiment is formed by bending the area located radially outside the pockets 21 obliquely inward in the radial direction. Specifically, the radially outer area bent portion 41 is formed by bending the radially outer edge of the fourth disc

portion 34, which is the outermost disc portion in the radial direction, upward in the axial direction to a predetermined angle.

The angle of the radially outer area bent portion 41, namely the angle between a radially inner surface 42 of the radially outer area bent portion 41 and an upper surface 43 of the fourth disc portion 34, is shown by an angle B_1 in FIGS. 2 and 3. This angle may be 0° , but is preferably an acute angle.

The radially outer area bent portion 41 has the projecting portions 44 formed in its tip end at positions aligned with the pockets 21. That is, the projecting portions 44 are formed at positions aligned with the pockets 21 and face inward in the radial direction. The positions aligned with the pockets 21 are such positions that the outer peripheral edges of the projecting portions 44 overlap the outer peripheral edges of the pockets 21. That is, the radially inner edge of the radially outer area bent portion 41 overlaps the radially outer edges of the pockets 21.

The projecting portions 44 project inward in the radial direction beyond the radially outer edges of the pockets 21 so as to contact the end faces 16 of the rollers 13 accommodated in the pockets 21. Namely, the projecting portions 44 abut on the end faces of the rollers accommodated in the pockets 21 to restrict movement of the rollers toward the outside in the radial direction. Specifically, the projecting portions 44 are shaped to extend continuously from the inner peripheral edge of the radially outer area bent portion 41 toward the inside in the radial direction. That is, the radially outer area bent portion 41 and the projecting portions 44 are formed as a single-piece member.

The projecting portions 44 are formed at circumferential positions so that the tips of the projecting portions 44 are located in the middle parts in the circumferential direction of the pockets 21. Specifically, the projecting portions 44 are formed so that their corners 45 on the surface 42 side, namely the innermost parts in the radial direction of the projecting portions 44 (the innermost corners 45 in the radial direction of the projecting portions 44) contact the centers of the end faces 16 of the needle rollers 13 accommodated in the pockets 21. In this example, the corners 45 are the corners of the projecting portions 44 which are located closer to the fourth disc portion 34.

The cage 11 has three pilot holes 51, 52. The three pilot holes 51, 52 serve as engagement portions for alignment. One of the pilot holes is not shown in FIG. 1. The three pilot holes 51, 52 are formed at intervals in the circumferential direction and extend straight through the cage 11 in the thickness direction of the cage 11. The three pilot holes 51, 52 open in a circular shape. The three pilot holes 51, 52 are formed substantially equally spaced apart from each other. In this example, the three pilot holes 51, 52 are formed at intervals of 120 degrees about the rotation axis 12 of the cage 11. Specifically, the pilot holes 51, 52 are formed in the middle part in the radial direction of the innermost first disc portion 31 in the radial direction. For example, the diameter of the pilot holes 51, 52 is $\phi 2.5$ mm or $\phi 3$ mm.

For example, the thrust roller bearing 20 having such a cage 11 includes the plurality of needle rollers 13, the upper bearing ring 14, and the lower bearing ring 15. When the thrust roller bearing 20 is in operation, the needle rollers 13 accommodated in the pockets 21 roll on a raceway surface 18 of the upper bearing ring 14 in the axial direction and a raceway surface 19 of the lower bearing ring 15 in the axial direction. The cage 11 rotates around its rotation axis 12. Each of the needle rollers 13 accommodated in the pockets 21 revolves while rotating around its axis. The needle rollers

13 are subjected to a radially outward centrifugal force. The centers of the end faces 16 of the needle rollers 13 make sliding contact with the projecting portions 44 of the cage 11, specifically the innermost corners 45 in the radial direction of the projecting portions 44 of the cage 11. That is, the corners 45 of the projecting portions 44 are the areas that contact the end faces 16 of the needle rollers 13.

The corners 45 have been press-flattened. The corners 45 subjected to the press-flattening process have no sharply pointed parts and smoothly connect to the surfaces forming the corners 45. This reduces aggression of the corners 45 against members that are contacted by the corners 45.

Next, a method for manufacturing the thrust roller bearing cage 11 according to the embodiment of the present invention will be described. The thrust roller bearing cage 11 is manufactured by using a transfer press. The transfer press is a relatively inexpensive press machine with a less complicated configuration. FIG. 4 is a flowchart illustrating representative steps of the method for manufacturing the thrust roller bearing cage 11 according to the embodiment of the present invention.

Referring to FIG. 4, a cage material, which will later become the cage 11, is first prepared (cage material preparing step: step S1). For example, the cage material is a thin flat steel sheet. At this stage, the cage material may be either a plate cut into a substantially rectangular shape or a circular plate, as the final outer shape of the cage is formed in an outer shape forming step (step S4) that will be performed later.

Next, concave and convex portions are formed in the cage material in the thickness direction of the cage material (concave and convex portions forming step: step S2). This ensures that the cage 11 has a large length dimension in the direction of its rotation axis even if the cage 11 is in the shape of a thin plate, whereby the cage 11 can appropriately retain the rollers.

Specifically, in this step, the cage material is subjected to a drawing process. In this case, the concave and convex portions can be formed more efficiently. FIG. 5 is a sectional view of the cage material after the concave and convex portions forming step. The section shown in FIG. 5 corresponds to the section shown in FIG. 2. Specifically, referring to FIG. 5, a flat plate-like cage material 56 is subjected to a drawing process to form first to fourth disc portions 61 to 64 and first to fourth cylindrical portions 66 to 69. A circular through bore 57 is formed in the central part of the cage material 56 so as to extend therethrough in the thickness direction. That is, in this case, the cage material 56 has what is called a mountain-and-valley shape made by bending the cage material 56 a plurality of times in the axial direction.

Thereafter, pilot holes serving as engagement portions are formed (pilot hole forming step: step S3). FIG. 6 is an enlarged sectional view showing a part of the cage material 56 after the pilot hole forming step. The section shown in FIG. 6 corresponds to the area VI in FIG. 2. A pilot hole 71 serving as an engagement portion is formed in the middle part in the radial direction of the first disc portion 61 so as to extend straight through the first disc portion 61 in the thickness direction. Three of the pilot holes 71 are formed in total so as to be substantially equally spaced apart from each other at intervals of 120 degrees in the circumferential direction.

Subsequently, the outer shape of the cage material 56 is formed (outer shape forming step: step S4). FIG. 7 is an enlarged sectional view showing a part of the cage material 56 after the outer shape forming step. The section shown in FIG. 7 corresponds to the area VI shown in FIG. 2, and is a

section taken along line VII-VII in FIG. 8. Specifically, in this example, the cage material 56 is punched straight in the thickness direction so that the cage 11 can be formed into the final outer shape by a radially outer area bending step (step S7) etc. that will be performed later. In this case, the outer shape of the cage material 56 can be formed relatively easily and accurately. A radially outer edge 72 of the cage 11, specifically, a radially outer edge 72 of the fourth disc portion 64, is thus formed.

When forming the outer shape, the cage material 56 is punched so as to form portions that will later become projecting portions 70. That is, in this case, the outer shape forming step is also a projecting portions forming step, i.e., the step of forming the projecting portions. FIG. 8 shows a part of the cage material 56 after a pocket forming step, which is the step following the outer shape forming step. FIG. 8 corresponds to FIG. 1. When punching the cage material 56 so as to form the projecting portions 70, the cage material 56 is aligned in the circumferential direction by using the plurality of pilot holes 71. Specifically, a plurality of guide pins (not shown), which serve as what is called pencil-like alignment jigs having a pointed end and having a tapered shape with its diameter gradually increasing from the pointed end, are prepared and are gradually inserted into the plurality of pilot holes 71 from one side in the thickness direction. The cage material 56 is thus aligned by using the plurality of guide pins and is punched into the overall outer shape with a punching machine (not shown) in view of the positions, the shape, etc. of the projecting portions 70. Accordingly, even if the cage material 56 is slightly out of alignment with the punching machine with respect to the proper positions where the projecting portions 70 are supposed to be formed, the cage material 56 can be aligned with the punching machine with respect to the proper positions where the projecting portions 70 are supposed to be formed, as the pencil-like guide pins having a pointed end are gradually inserted into the pilot holes 71. The punching process can thus be performed. In this example, since the cage material 56 has the three pilot holes 71, rotation etc. of the cage material 56 is prevented during alignment. The cage material 56 can thus be aligned more accurately.

Subsequently, pockets are formed (pocket forming step: step S5). FIG. 9 is an enlarged sectional view showing a part of the cage material after the pocket forming step. The section shown in FIG. 9 corresponds to the area III shown in FIG. 2 and is a section taken along line IX-IX in FIG. 8. In this example, each pocket 73 is punched out along a part of the second disc portion 62, the third disc portion 63, and a part of the fourth disc portion 64 and also along the third cylindrical portion 68 and the fourth cylindrical portion 69 so as to extend straight through the cage material 56 in the thickness direction. Although not shown in FIG. 9, the upper roller stoppers and the lower roller stoppers, which are shaped so as to project into the pockets 73 in the circumferential direction, are formed simultaneously with the pockets 73. That is, the pockets 73 are punched out in view of the shape of the upper roller stoppers and the lower roller stoppers so as to conform to the outer shape of needle rollers 13 that are to be accommodated in the pockets 73. The plurality of pockets 73 may be punched out either all at once or one by one.

When forming the pockets 73 in the cage material 56, the pilot holes 71 are also used to align the cage material 56 to be punched with a punching machine (not shown) for punching out the pockets. That is, the pockets 73 are formed with respect to the positions of the pilot holes 71. As in the case of the outer shape forming step, alignment in the

circumferential direction is performed by using the plurality of pilot holes 71. Specifically, a plurality of guide pins serving as sharp pencil-like alignment jigs are prepared and the tip ends of the guide pins are gradually inserted into the plurality of pilot holes 71 from one side in the thickness direction as described above. The cage material 56 is thus aligned by using the plurality of guide pins, and the pockets 73 are punched out with the punching machine in view of the positions, shape, etc. of the pockets 73. The pockets 73 are thus formed in phase with the projecting portions 70 in the circumferential direction, so that an appropriate positional relationship can be established between the pockets 73 and the projecting portions 70. Accordingly, the projecting portions 70 can be accurately and efficiently formed in terms of the positional relationship of the projecting portions 70 with the pockets 73 to be formed. Since the projecting portions 44 (see FIG. 3) are accurately formed at the appropriate positions, end faces 16 of the needle rollers 13 can appropriately contact the projecting portions 44 when the bearing is in operation. The plurality of pockets 73 may be punched out either all at once or one by one.

In the present embodiment, the pilot holes 71 are formed in an area located radially inside the pockets 73. In this case, the pilot holes 71 can be formed by making effective use of the available area of the cage 11.

In the present embodiment, the pilot holes 71 are formed so as not to overlap the pockets 73 in the circumferential direction. This can avoid local strength reduction in the circumferential direction of the cage 11. The positional relationship of the pockets 73 with the pilot holes 71 can be determined as desired. Specifically, in this example, the plurality of pockets 73 are formed so that each of the pilot holes 71 is located at a position corresponding to the middle in the circumferential direction between adjoining ones of the pockets 73.

Subsequently, as shown in FIGS. 8 and 9, an annular groove 79 is formed at a position radially outside the pockets 73 in the cage material (groove forming step: step S6). In this step (step S6), the annular groove 79 is formed at such a position that the cage material is to be bent along the annular groove 79 when forming a radially outer area bent portion 41 in the radially outer area bending step (step S7) which will be described below. A method for forming the groove 79 is not particularly limited. The groove 79 may be formed by pressing, cutting, etc., and it is preferable to form the groove 79 by pressing the cage material with a ring-shaped wedge. The shape of the groove 79 is not particularly limited. The groove 79 may have a pointed bottom or may have a curved bottom. The steps S4 to S6 may be performed in any order.

Subsequently, an area of the cage material 56 which is located radially outside the pockets 73 is bent inward in the radial direction along the groove 79 to form a radially outer area bent portion (radially outer area bending step) (step S7). In this step, since the radially outer area of the cage material 56 is bent along the groove 79, the bending position can be easily controlled, whereby positional accuracy can be improved and the radially outer area of the cage material 56 can be easily bent inward in the radial direction. In this step, it is preferable to form the radially outer area bent portion by bending the radially outer area of the cage material 56 obliquely inward in the radial direction to an acute tilt angle.

FIG. 10 is an enlarged sectional view showing a part of the cage material during the radially outer area bending step. FIGS. 11 and 12 are enlarged sectional views illustrating how the radially outer area bending step is performed. FIGS. 13 and 14 are enlarged sectional views showing a part of the

cage material 56 after the radially outer area bending step. The sections shown in FIGS. 10 and 13 correspond to the area VI in FIG. 2. The section shown in FIG. 14 corresponds to the area III in FIG. 2. The sections shown in FIGS. 11 and 12 show the positional relationship of an area of the cage material 56 which is located radially outside the position corresponding to the area VI in FIG. 2 with holding members 101, 102 and a pressing member 103. In this example, as shown in FIG. 10, the annular radially outer edge 72 of the cage material 56 is first bent along the entire circumference along the groove 79 so as to extend straight in the thickness direction. That is, the angle B_2 between a radially inner surface 75 of a radially outer area bent portion 74 and an upper surface 76 of the fourth disc portion 64 is approximately a right angle. For example, the radially outer edge 72 is bent to a right angle by the following method, although the present invention is not particularly limited to this method. As shown in FIG. 11, the entire cage material 56 except for a radially outer area of the fourth disc portion 64 is sandwiched between the holding members 101, 102 in the vertical direction and is held therebetween, and the pressing member 103 is placed under the radially outer area of the fourth disc portion 64. As shown in FIG. 12, the pressing member 103 is then moved upward. The radially outer area bent portion 74 can thus be formed at a right angle with respect to the fourth disc portion 64.

Subsequently, as shown in FIGS. 13 and 14, the radially outer area bent portion 74 is tilted further inward in the radial direction to form the radially outer area bent portion 74. As shown in FIGS. 13 and 14, the trace 29 of the annular groove along which the radially outer area of the cage material 56 is bent is left in this step.

The bending angle (tilt angle), that is, the angle between the radially inner surface 75 of the radially outer area bent portion 74 and the upper surface 76 of the fourth disc portion 64 is shown by an angle B_3 in FIGS. 13 and 14. The angle B_3 corresponds to the angle B_1 described above. In other words, the angle B_1 is equal to the angle B_3 . The angles B_1 , B_3 are preferably an acute angle.

In this example, in terms of the positional relationship in the circumferential direction, the projecting portions 70 are formed at the positions corresponding to the middle parts in the circumferential direction of the pockets 73. The projecting portions 70 are thus formed at appropriate positions. Since the radially outer area bent portion 74 is bent at a desired position due to the annular groove 79, the projecting portions 70 are formed at appropriate positions. Specifically, the projecting portions 70 abut on the centers of the end faces 16 of the needle rollers 13 at their corners 77 located closer to the fourth disc portion 64. Finally, the areas of the projecting portions 70 which are to contact the end faces 16 of the needle rollers 13 are subjected to a press-flattening process. The thrust roller bearing cage 11 configured as shown in FIGS. 1 to 3 is thus manufactured.

The step of tilting the radially outer edge 72 of the cage material 56 inward in the radial direction after the annular radially outer edge 72 is bent so as to extend straight in the thickness direction and the press-flattening process may be performed successively. FIG. 15 is an enlarged sectional view illustrating how the radially outer area bending step is performed. FIG. 16 is an enlarged sectional view illustrating how the press-flattening step is performed. FIG. 17 is an enlarged sectional view showing the tip of the radially outer area bent portion after the press-flattening step.

Specifically, as shown in FIG. 15, after the cage material 56 is bent so that the radially outer area bent portion 74 extends at a right angle with respect to the fourth disc

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portion 64, an area of the cage material 56 which is located radially inside the radially outer area bent portion 74 is sandwiched between dies 104, 105 in the vertical direction and is held therebetween. At this time, the radially outer edge of the upper die 104 is located radially inside the radially outer edge of the lower die 105. A die 106 that presses the radially outer area bent portion 74 downward from above is also placed so as to contact a radially outer surface 78 of the radially outer area bent portion 74. The die 106 includes a radially inner end face 106a that faces the upper die 104 and extends in the vertical direction, a horizontal face 106b that is continuous with the radially inner end face 106a and extends outward in the radial direction, and a radially inner face 106c that faces the radially outer surface 78 of the radially outer area bent portion 74 and extends in the vertical direction. A part 106d of the die 106 where the horizontal face 106b and the radially inner face 106c meet has a round (R) shape. When the die 106 is moved downward so that the radially inner end face 106a moves along a radially outer end face 104a of the die 104, the radially outer area bent portion 74 can be tilted inward in the radial direction as guided by the round part 106d. As shown in FIG. 16, the annular groove 79 thus leaves the trace 29 that is a compression mark formed by pressing.

Subsequently, as shown in FIG. 16, the die 104 is moved further downward so that the radially inner corner of the radially outer area bent portion 74 is smoothed by the radially outer end face 104a of the die 104 and the radially outer corner of the radially outer area bent portion 74 is smoothed by the horizontal face 106b of the die 106. As shown in FIG. 17, the projecting portions 70 subjected to the press-flattening process in the areas of the projecting portions 70 which are to contact the end faces of the rollers can be formed in this manner.

As described above, according to the thrust roller bearing cage 11 of the present embodiment and the method for manufacturing the same, the annular groove 79 is formed at a position radially outside the pockets 73 in the groove forming step (step S6), and the radially outer area of the cage material is bent inward in the radial direction along the groove 79 in the radially outer area bending step (step S7) to form the radially outer area bent portion 74. Since the radially outer area of the cage material is bent along the annular groove 79, the bending position can be controlled. Moreover, the annular groove 79 facilitates bending of the radially outer area of the cage material even when the rim portion that is bent has a small length in the radial direction. Accordingly, regarding the projecting portions that are formed in the tip end of the radially outer area bent portion 42, those parts of the projecting portions which are to contact the centers of the end faces of the needle rollers can be accurately aligned, whereby running torque can be reduced. A trace of the annular groove 79 is left in such a cage 11.

In the above embodiment, the corners of the projecting portions which are located closer to the fourth disc portion contact the centers of the end faces of the needle rollers accommodated in the pockets. However, the present invention may have the following configuration. FIG. 18 is a sectional view showing a part of a cage having this configuration. FIG. 18 corresponds to the section shown in FIG. 3.

Referring to FIG. 18, a thrust roller bearing cage 81 according to another embodiment of the present invention has a radially outer area bent portion 82 having projecting portions 83 formed at positions corresponding to the posi-

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tions of pockets 85. The projecting portions 83 contact the centers of end faces 16 of needle rollers 13 accommodated in the pockets 85 at corners 84 located on the opposite side of the projecting portions 83 from a fourth disc portion 86. The corners 84 have been press-flattened. This configuration can be achieved by machining the corners 84 with a jig angled so as to conform to the corner 84 in the radially outer area bending step. A trace 89 of an annular groove along which the radially outer area bent portion 82 is bent is left in the cage 81 shown in FIG. 18.

A pilot hole may be formed at a position where a pocket is supposed to be formed. In other words, one of the plurality of pockets may be used as a pilot hole. FIG. 19 shows a part of a cage having this configuration. Referring to FIG. 19, a thrust roller bearing cage 91 according to still another embodiment of the present invention includes a plurality of pockets 92 and pillars 93 each located between adjoining two of the pockets 92. A pilot hole 95 is formed at a position where a pocket 92 is supposed to be formed in a pillar 94 located between the pockets 92. In this configuration, one of the plurality of pockets 92 that are formed equally spaced apart from each other in the circumferential direction is replaced with this pilot hole 95.

In the above embodiment, the pilot holes extend straight through the cage in the thickness direction. However, the present invention is not limited to this. For example, the pilot holes extending through the cage may have a tapered wall surface. The pilot holes are not limited to the circular holes and may be quadrilateral holes, triangular holes, etc. The pilot holes are formed as engagement portions. However, the present invention is not limited to this. The engagement portions may have other configurations. For example, the engagement portions may be formed by cutouts.

In the above embodiment, a drawing process is performed in the concave and convex portions forming step. However, the present invention is not limited to this. A process other than the drawing process, such as a bending process, may be used to form concave and convex portions.

In the above embodiment, the cage has the concave and convex portions that are formed in the thickness direction. However, the present invention is not limited to this. The cage may not have the concave and convex portions that are formed in the thickness direction, and a cage in the form of what is called a laminate of two plates may be used.

In the above embodiment, the thrust roller bearing having such a cage as described above may not have bearing rings. Rollers other than the needle rollers, such as long rollers etc., may be used.

The embodiments disclosed herein are by way of example in all respects and should not be interpreted as restrictive. The scope of the present invention is defined by the claims rather than by the above embodiments, and the invention is intended to cover all changes and modifications within the spirit and scope of the invention as defined by the claims.

INDUSTRIAL APPLICABILITY

The thrust roller bearing cage according to the present invention and the method for manufacturing the same are effectively utilized to meet demands for thrust roller bearing cages with excellent performance and more efficient methods for manufacturing such a thrust roller bearing cage.

REFERENCE SIGNS LIST

11, 81, 91 Cage
12 Rotation Axis

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13 Roller
 14, 15 Bearing Ring
 16, 17 End Face
 18, 19 Raceway Surface
 20 Thrust Roller Bearing
 21, 73, 85, 92 Pocket
 22, 57 Through Bore
 23, 24 Annular Portion
 25, 93, 94 Pillar
 26, 27, 28 Roller Stopper
 29, 89 Trace
 31, 32, 33, 34, 61, 62, 63, 64, 86 Disc Portion
 36, 37, 38, 39, 66, 67, 68, 69 Cylindrical Portion
 41, 74, 82 Radially Outer Area Bent Portion
 42, 43, 75, 76, 78 Surface
 44, 70, 83 Projecting Portion
 45, 77, 84 Corner
 51, 52, 71, 95 Pilot Hole
 56 Cage Material
 72 Edge
 79 Groove
 101, 102 Holding Member
 103 Pressing Member
 104, 105, 106 Die
 104a Radially Outer End Face
 106a Radially Inner End Face
 106b Horizontal Face
 106c Radially Inner Face
 106d Part
 The invention claimed is:
 1. A thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers, comprising:
 a radially outer area bent portion formed by bending the cage inward in a radial direction along an annular groove formed at a position radially outside the pockets; and

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projecting portions that are formed in a tip end of the radially outer area bent portion at positions aligned with the pockets and project inward in the radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets, wherein
 a trace of the groove is left at a position along which the cage is bent.
 2. The thrust roller bearing cage according to claim 1, wherein
 areas of the projecting portions which are to contact the end faces of the rollers are subjected to a press-flattening process.
 3. A method for manufacturing a thrust roller bearing cage included in a thrust roller bearing and including a plurality of pockets accommodating rollers, comprising the steps of:
 preparing a cage material that will later become the cage; forming an outer shape of the cage material so that the outer shape has portions that will later become projecting portions projecting inward in a radial direction beyond radially outer edges of the pockets so as to contact end faces of the rollers accommodated in the pockets;
 forming the pockets in the cage material;
 forming an annular groove at a position radially outside the pockets in the cage material; and
 forming a radially outer area bent portion by bending an area of the cage material which is located radially outside the pockets inward in the radial direction along the annular groove.
 4. The method for manufacturing the thrust roller bearing cage according to claim 3, further comprising the step of: press-flattening areas of the projecting portions which are to contact the end faces of the rollers.

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